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IS 7806 (1993): Martensitic and austenitic high alloy steel castings for high temperature service [MTD 14: Foundry]

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( दूसरा पुनरीक्षण )

*Indian Standard*

MARTENSITIC STEEL AND AUSTENITIC  
HIGH ALLOY STEEL CASTINGS FOR HIGH  
TEMPERATURE CORROSION SERVICES —  
SPECIFICATION

*( Second Revision )*

UDC 669.15-194.55/56-14

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NEW DELHI 110002

## FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Steel Castings Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1975 and was revised in 1985. While reviewing the standard in the light of the experience gained during these years the committee decided that the standard may be further revised. In this revision, the requirements of three more grades have been included and the various clauses have been aligned with the recent standards on steel castings.

Steel castings covered by this standard include 22 grades of material suitable for corrosive applications involving elevated temperature up to about 600°C and are used in various industries, such as chemical processing equipment, petroleum refinery applications and high temperature bolting applications. The alloy combinations of these castings are mainly iron-chromium, iron-chromium-nickel and iron-chromium-nickel-molybdenum. These castings possess varying degrees of suitability for high temperature and corrosion resistant service. It is the responsibility of the purchaser to determine which grade shall be furnished, due consideration being given to the service requirements.

In the preparation of this standard, assistance has been derived from ASTM A 351/A351 M-1988 'Austenitic steel castings for high temperature service', ASTM A743/A 743M-88 'Specification for castings, iron-chromium, iron, chromium-nickel, corrosion resistant for general applications' and ASTM A 217/A-217M : 1987 Martensitic stainless and alloy steel castings for pressure containing parts suitable for high temperature service issued by the American Society for Testing and Materials.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

## *Indian Standard*

# MARTENSITIC STEEL AND AUSTENITIC HIGH ALLOY STEEL CASTINGS FOR HIGH TEMPERATURE CORROSION SERVICES — SPECIFICATION

## *(Second Revision)*

### **1 SCOPE**

This standard covers the requirements for steel castings for various grades of martensitic and austenitic steel castings for high temperature corrosion services.

### **2 REFERENCES**

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

### **3 TERMINOLOGY**

**3.1** For the purpose of this standard, the following definitions shall apply.

#### **3.1.1 Cast (Melt)**

The product of any of the following:

- a) One furnace heat,
- b) One crucible heat, or
- c) A number of furnace or crucible heats of similar composition mixed in a ladle or tapped in separate ladles and poured simultaneously for making a casting.

#### **3.1.2 Batch**

A group of castings of one grade of material, cast from the same melt and heat-treated together under identical conditions.

### **4 GRADES**

This standard covers a total of 22 grades of steel castings. Two grades are of martensitic and other 20 are for austenitic steel castings for use at high temperature.

### **5 SUPPLY OF MATERIAL**

General requirements relating to supply of steel castings shall be as laid down in IS 8800 : 1986.

### **6 MANUFACTURE**

The steel for the castings shall be made by electric arc or electric induction or such other processes as may be agreed to between the purchaser and the manufacturer.

### **7 PARTICULARS TO BE SPECIFIED WHILE ORDERING**

For the benefit of the purchaser, particulars to be

specified while ordering for steel castings to this specification are given in Annex B.

### **8 CHEMICAL COMPOSITION**

**8.1** The ladle analysis of steel when carried out either by the method specified in IS : 228 and its relevant parts or any other established instrumental/chemical methods shall be as given in Table 1. In case of dispute the procedure given in IS : 228 shall be the referee method. However, where the method is not given in IS : 228, the referee method shall be as agreed to between the purchaser and the manufacturer.

**8.2** The manufacturer shall carry out analysis from a sample of each melt of steel and, if so specified by the purchaser at the time of enquiry and order, shall supply a test certificate of chemical analysis of the sample of steel for each melt.

#### **8.3 Product Analysis**

If specified at the time of enquiry and order, the product analysis may be carried out from a test piece or from a casting representing each melt. Drillings for analysis shall be taken from not less than 6 mm beneath the cast surface, and in such a manner as not to impair the usefulness of any casting selected. The permissible variation in product analysis from the limits specified in Table 1 shall be as given in IS 6601 : 1987.

#### **8.4 Residual Elements**

**8.4.1** Elements not specified in Table 1 shall not ordinarily be added to the steel and all reasonable precautions shall be taken to prevent contamination from the scrap etc to keep them as low as practicable.

**8.4.2** Analysis and reporting of the analysis in the test certificate for the residual elements shall be done only when so specified by the purchaser in the enquiry and order. However, the manufacturer shall ensure that the residual elements are within the limits, when such limits are specified by the purchaser in the enquiry and order.

### **9 WORKMANSHIP AND FINISH**

**9.1** The castings shall be accurately moulded in accordance with the pattern or the working drawings supplied by the purchaser with the addition of such letters, figures and marks as may be specified.

**Table 1 Chemical Composition for Martensitic and Austenitic Steel Castings for High Temperature Service**  
( Clause 8 )

Constituent, Percent*	Grades, Requirements, Percent*																		
	1	1A	2& 2A	3& 3A	4& 4A	5	5A	6	7	8	9	10	11	12	13	14	15	16	17
Carbon	0.15	0.15	0.03	0.08	0.03	0.08	0.08	0.08	0.10	0.20	0.20	0.25 to 0.35	0.35 to 0.45	0.25 to 0.35	0.10	0.07	0.08	0.04	0.05 to 0.15
Silicon	1.50	0.65	2.00	2.00	1.50	1.50	2.00	1.50	2.00	2.00	1.75	1.75	1.75	2.50	1.50	1.50	1.50	1.00	0.50 to 1.50
Manganese	1.00	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	2.00	1.50	1.50	1.50	1.00	0.15 to 1.50
Sulphur	← 0.040 →																		
Phosphorus	← 0.040 →																		
Chromium	11.5 to 14.0	11.5 to 14.0	17.0 to 21.0	18.0 to 21.0	17.0 to 21.0	18.0 to 21.0	18.0 to 21.0	22.0 to 26.0	22.0 to 26.0	22.0 to 27.0	23.0 to 27.0	23.0 to 27.0	23.0 to 27.0	13.0 to 17.0	15.0 to 18.0	19.0 to 22.0	24.5 to 26.5	19.0 to 21.0	
Nickel	1.00 to 12.0	1.00 to 11.0	8.00 to 13.0	8.00 to 12.0	9.0 to 12.0	9.0 to 12.0	12.0 to 15.0	12.0 to 15.0	12.0 to 15.0	19.0 to 22.0	19.0 to 22.0	19.0 to 22.0	19.0 to 22.0	33.0 to 37.0	13.0 to 16.0	27.5 to 30.5	9.0 to 13.0	4.75 to 6.00	31.0 to 34.0
Molybdenum	0.50 to 1.00	0.75 to 3.0	—	—	2.0 to 3.0	2.0 to 3.0	—	—	—	—	—	—	—	0.50 to 2.25	1.75 to 3.0	2.0 to 4.0	3.0 to 2.25	—	
Niobium	—	—	—	—	—	—	†	—	—	—	—	—	—	—	—	—	—	—	
															‡ Copper 3.0 to 4.0	Copper 2.75 to 3.25	0.15 to 1.50		

\*Maximum, except where range is specified.

†Grade 5A shall have a Niobium content of not less than 8 times the carbon content but not over 1.00 percent.

‡Grade 13 shall have a Niobium content of not less than 10 times the carbon content but not over 1.20 percent.

**9.2** The purchaser shall specify the tolerances on all important dimensions. On other dimensions, tolerances specified in IS 4897:1986 shall apply.

## 10 FREEDOM FROM DEFECTS

**10.1** All castings shall be free from defects that will adversely affect machining or utility of castings.

**10.2** When necessary to remove risers or gates by flame or arc or a combination thereof, or by any other process involving intense heat, care shall be taken to make the cut at a sufficient distance from the body of the casting so as to prevent any defect being introduced into the casting due to local heating. Any such operation is preferably done before final heat treatment.

**10.3** In the event of any casting proving defective from foundry causes in the course of preparation, machining or erection, such casting may be rejected notwithstanding any previous certification of satisfactory testing and/or inspection.

## 11 FETTLING AND DRESSING

All castings shall be properly fettled and dressed, and all surfaces shall be thoroughly cleaned.

## 12 HEAT TREATMENT

**12.1** The castings shall be heat-treated in a properly constructed furnace, having adequate means of temperature control which shall permit the whole of the castings being uniformly heated to the necessary temperature. All castings shall be suitably heat treated so as to attain the specified mechanical properties.

**12.2** Unless otherwise specified in the enquiry and order or agreed to between the purchaser and the manufacturer, all castings shall be suitably heat treated except grades 10, 11, 12, and 17 which shall be supplied in the as cast condition.

**12.2.1** The martensitic Grades 1 and 1A shall be supplied in the normalized and tempered condition. Tempering shall be at a minimum of 590°C.

**12.2.2** The other grades shall be supplied in solution treated condition.

**12.2.3** Heat treatment shall be performed on grade 16 after the casting has been allowed to cool below the transformation range.

**12.3** The test pieces shall be heat treated along with the castings they represent.

### 13 MECHANICAL TESTS

**13.1** The mechanical properties specified are those which are to be obtained from test bars cast either separately from or attached to the castings to which they refer and heat treated as given in 12. The test values so exhibited, therefore, represent the quality of steel from which the castings have been poured; they do not necessarily represent the properties of the castings themselves.

**13.2** The tensile test shall be carried out in accordance with IS 1608 : 1972. The relevant mechanical properties shall be as given in Table 2.

### 14 HYDROSTATIC TEST

**14.1** When so specified by the purchaser, in the enquiry and order a hydraulic test shall be carried out; the details of the test shall be as agreed to between the purchaser and the manufacturer.

**14.2** The castings shall not be peened, plugged or impregnated to stop leakages. However, unless specified at the time of enquiry and order, rectification

and upgradation of a casting by welding may be carried out in accordance with the approved procedures as laid down in the relevant clause of the standard.

### 15 NON-DESTRUCTIVE TESTS

**15.1** Non-destructive testing shall be applied if specified in the enquiry and the order. Under this heading are grouped the tests, which aim at revealing defects which cannot be revealed by a simple visual examination, such as penetrant, magnetic particle, ultrasonic, X-radiographic, or gamma-radiographic inspection; also included under this heading are tests on the surface condition by visual or visual-tactile examination. The purchaser shall specify in the enquiry and order:

- a) the type of non-destructive testing which the intends to carry out or to have carried out;
- b) the area or areas of the casting to which these tests apply, and the types of discontinuity, where relevant;
- c) the severity level defining the acceptability or non-acceptability of defects which may be revealed; and
- d) whether the manufacturer is or is not contractual responsible for carrying out the tests.
- e) whether the manufacturer is or is not contractually responsible for carrying out the test.

**Table 2 Mechanical Properties for Martensitic and Austenitic Steel Castings for High Temperature Service  
( Clause 13 )**

Property	Requirement, Grades																					
	1	1A	2	2A	3	3A	4	4A	5	5A	6	7	8	9	10	11	12	13	14	15	16	17
Tensile strength, MPa, Min	620	755	480	530	480	530	480	550	480	480	450	480	480	450	450	450	480	430	515	690	435	
Yield stress, MPa, Min	450	550	210	240	210	240	210	260	210	210	190	210	210	190	240	240	190	210	170	240	485	170
Elongation, percent, Min	16	15	33	33	33	33	29	29	29	29	29	29	29	29	10	10	15	19	33	23	15	19
Reduction in area, percent, Min	30.0	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

#### NOTES

1 In case of Grade 3A and 4A the properties given are obtained by adjusting the chemical composition within the limits given in Table 1 to obtain a ferrite-austenite ratio which will result in the higher ultimate and yield strength indicated.

2 Because of the thermal instability of Grades 2A, 3A, and 4A, they are not recommended for service at temperatures in excess of 430°C.

**15.2** Unless otherwise agreed upon, when non-destructive testing is to be done, the castings shall be examined as follows:

- a) Ultrasonic examination as per IS 7666 : 1988,
- b) Magnetic particle examination as per IS 3703:1980,
- c) Liquid penetrant examination as per IS 3658: 1981; and
- d) Radiographic examination as per IS 2595 : 1978.

**15.3** Unless otherwise agreed upon the following shall be the acceptance standards:

- a) IS 9565 : 1986 For ultrasonic inspection.
- b) IS 10724 : 1988 Magnetic particle inspection.
- c) IS 11732 : 1986 For dye penetrant inspection.
- d) IS 12938 : 1990 For radiographic inspection.

NOTE — In case of austenitic grades, ultrasonic examination and magnetic particle examination may not ordinarily be feasible.

#### 15.4 Microstructure

**15.4.1** In case of austenitic steel castings, if required by the purchaser, the maximum permissible percentage of ferritic in the microstructure shall be stipulated at the time of enquiry and order.

NOTE — The sample for metallographic examination shall be taken from the relevant test block.

**15.4.2** The austenitic steel castings shall either be fully nonmagnetic or feebly magnetic depending on the actual composition balance within the specified range. If required by the purchaser, the permissible degree of magnetism shall be the subject of agreement between the purchaser and the manufacturer or shall be as specified at the time of enquiry and order.

### 16 REPAIR OF CASTINGS

**16.1** Unless otherwise specified by the purchaser in the enquiry and order, castings may be rectified by welding. All repairs by welding shall be carried out in accordance with the procedure laid down in IS 5530 : 1986. If castings have been subjected to non-destructive or hydraulic testing by agreement between the purchaser and the manufacturer, the

castings shall be re-examined in the area of repair following any rectifying operation performed on the castings.

**16.2** To form the basis of an agreement between the purchaser and the supplier in this respect where relevant, the following classification shall apply concerning the extent of repair:

- a) Weld repair involving a depth not exceeding 20 percent of wall thickness or 25 mm, whichever is lower, shall be termed as a minor repair.
- b) Any weld repair exceeding the above shall be termed as a major repair. Also any single repair having an area exceeding  $250 \text{ mm}^2$  for every millimetre of wall thickness shall also be deemed to be a major repair, regardless of the considerations mentioned in (a) above.

**16.3** The welding procedure to be followed for any welding that may be required on the surface hardened area shall be as agreed mutually.

### 17 SAMPLING

The method of sampling the steel castings for the purpose of chemical analysis and mechanical tests including re-test shall be in accordance with IS 6907:1973.

### 18 MARKING

**18.1** Each casting shall be legibly marked with the following:

- a) The number or identification mark by which it is possible to trace the melt and the heat-treatment batch from which it was made;
- b) The manufacturer's initials or trade-mark; and
- c) Other identification marks in accordance with the agreement between the purchaser and the manufacturer.

NOTE : It is recommended that a minimum of markings be used.

**18.2** By agreement between the purchaser and the manufacturer, castings complying with the requirements of this standard may, after inspection, be legibly marked with an acceptance mark.

**18.2.1** The castings may also be marked with the Standard Mark.

## ANNEX A

( Clause 2 )

### LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
228	Methods for chemical analysis of steels	6907 : 1992	Methods of sampling steel castings ( <i>second revision</i> )
1608 : 1972	Methods for tensile testing of steel products ( <i>first revision</i> )	7666 : 1988	Recommended procedure for ultrasonic examination of ferritic castings of carbon and low alloy Steel ( <i>first revision</i> )
2595 : 1978	Code of practice for radiographic testing ( <i>first revision</i> )	8800 : 1986	Technical delivery conditions for steel castings ( <i>second revision</i> )
3658 : 1981	Code of practice for liquid penetrant flaw detection	9565 : 1986	Acceptance standards for ultrasonic inspection of steel castings ( <i>first revision</i> )
3703 : 1980	Code of practice for magnetic particle flaw detection	10724 : 1988	Acceptance standards for magnetic particle inspection steel castings
4897 : 1986	Deviations for untoleranced dimensions and mass of steel casting ( <i>first revision</i> )	11732 : 1986	Acceptance standards for dye penetrant inspection of steel castings
5530 : 1987	Code of procedure for repair and rectification of steel castings by metal arc welding process ( <i>first revision</i> )	12938 : 1990	Acceptance standards for radiographic inspection of steel castings
6601 : 1987	Permissible deviations in chemical composition for product analysis of steel castings ( <i>first revision</i> )		

## ANNEX B

( Clause 7 )

### INFORMATION TO BE SUPPLIED BY THE PURCHASER

#### B-1 BASIS FOR ORDER

While placing an order for the purchase of steel castings covered by this standard, the purchaser should specify the following:

- a) Material specification;
- b) Drawing or reference number of the pattern (if supplied by the purchaser), along with a copy of the drawing;

- c) Optional/additional tests required, if any;
- d) Whether the castings are to be inspected and tested in the presence of the purchaser's representative;
- e) Any special requirement; and
- f) Test report, if required.

### **Standard Mark**

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